An Innovative Approach to Multiparticle Three-Dimensional Imaging

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For many years two-dimensional (2D) and three-dimensional (3D) fragment imaging techniques have been successfully used in the study of molecular dissociation process or photo-emission. The two important features of a 3D imaging detector are the ability to measure both time and position with good resolution, and the possibility to measure simultaneously, the arrival of multiple fragments. The required resolution is typically ~ 100 μm in position measurement and ~ 1 ns in time measurement.

The essential difficulty in any readout design is the requirement to measure simultaneously correlated time and position of many particles with good resolution. In most of the 3D detectors, the necessary resolution can be achieved, but the number of particles which can be detected is limited. In this work, we present a new scheme for a multi-particle 3D imaging detector, which allows for the simultaneous measurement of both arrival time and position of particles, the number of particles being practically unlimited, as long as they do not hit the detector at the same position in the same event. Furthermore, this scheme has the advantage of locating the readout system outside the vacuum chamber, as only optical coupling is used. The position and time resolution achieved with such a system is presently 50 μm and ~ 1 ns respectively, but better time resolution is possible.

The basic idea behind the new scheme for 3D imaging is as follow: The first detection stage is made of a standard MCP detector, with a phosphor screen as an anode. Each particle impact on the MCP induces an electron shower which locally excites the phosphor screen. The excited spot on the phosphor screen decays with a characteristic time (τ) which is dependent on the properties of the phosphor screen, but not on the type, velocity, mass or charge of the incoming particle. The second detection stage consists of two CCD cameras, focused on the phosphor screen and a fast optical shutter in front of one of the cameras. This fast shutter is open until a certain time t_g. Thus, both images registered by the CCD cameras are identical, except for the light intensity of each pixel of the second camera which is a function of the time of arrival of the particle and t_g. By digitizing (integrating) the position and light emission produced by the phosphor screen, and subsequently dividing the two images, it is possible to obtain both position (directly from one of the images) and time information for each pixel on the screen.

Using such a scheme, we have demonstrated position resolution of the order of 50 μm and nanosecond time resolution for multiplarticle events. There is absolutely no limit on the smallest time difference which can be measured, i.e., it is possible to measure correlated time and position for many particles, even when $\Delta t \rightarrow 0$.

More details can be found in D. Strasser, X. Urbain, H. B. Pedersen, N. Altstein, O. Heber, R. Wester, K. G. Bhushan, and D. Zajfman, *An Innovative Approach to Multiparticle Three-Dimensional Imaging.* Rev. Sci. Instruments, 3092-3098, 71 (2000).